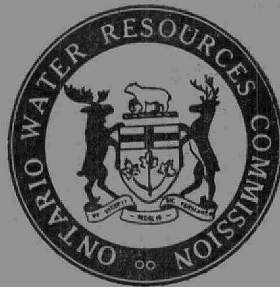


CA2 ON
WR. . .
1966
C51



O.W.R.C.
Industrial Wastes
Survey

THE
ONTARIO WATER RESOURCES
COMMISSION



THE COBALT CAMP

A PRELIMINARY ASSESSMENT OF
WATER POLLUTION BY MINING
WASTES IN THE COBALT AREA

1967

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

CAZ ON

WR....

1966

C51

THE COBALT CAMP

A Preliminary Assessment of
Water Pollution by Mining
Wastes in the Cobalt Area

1966

FEB 27 1992

TABLE OF CONTENTS

INTRODUCTION	1
SUMMARY	1
SECTION I - THE COBALT AREA	
Boundaries	3
Topography	3
Drainage	4
Land Use	4
SECTION II - THE PRESENT SITUATION	6
SECTION III - NATURE, EXTENT AND EFFECTS OF THE PROBLEM	
Nature	34
Extent	40
Effects	42
SECTION IV - THE SOLUTION	44
SECTION V - RECOMMENDATIONS	52
ACKNOWLEDGMENTS	53
APPENDICES	
Appendix 1 - Silver	54
Appendix 2 - The Cobalt Camp	65
Appendix 3 - Analytical Results	102
In Pocket	
Appendix 4 - Cobalt Area	
Topographical Map	
Appendix 5 - Cobalt Area	
Aerial Photographic Mosaic	

INTRODUCTION

Mining operations have been carried on in the Cobalt area since the beginning of the present century. Little or no thought was given to the proper disposal of mill tailings, with the result that today much of the water resources of the area is unfit for human use or recreational activity.

This survey was carried out as a preliminary assessment of the nature, extent and effects of pollution (past, present and future) by mining wastes in the Cobalt area.

The report describes the general characteristics of the area, surface water systems and land use. Since the report is primarily concerned with water pollution resulting from mining operations, various aspects of this industry are considered in some detail.

Recommendations are made for further study in depth of the area.

SUMMARY

In 1903, silver was found at Long Lake 103 miles north of North Bay. In the more than sixty years since that time, the Cobalt Camp has produced more than 500,000,000 ounces of the white metal.

Due to the absence of a programme of water resources management, a serious pollution problem has resulted from the discharge of mill tailings to the lakes of the area. Lakes have been filled with

tailings in such a manner that the drainage streams carry off the material, deposit it along their courses and transport it to bodies of water not directly affected by the original disposal of the waste. In this way, much of the water resources of the area has been contaminated by solids and arsenic, rendering these resources unfit for most uses.

Rehabilitation of the lakes into which tailings have been discharged, by returning them to their original condition, is impossible, but progressive pollution of other lakes and watercourses, due to the transport of tailings away from the original disposal sites, can and should be prevented.

Resolution of the problem will be complicated by the fact that many of the mining companies responsible for the pollution are now defunct, and it would appear that much of the responsibility for implementation of any palliative measures adopted will fall to the Government of Ontario.

SECTION I
THE COBALT AREA

Boundaries (Appendix 4)

The camp is located almost entirely⁴ in the Township of Coleman, but an effective consideration of the area must include part of the Township of Gillies Limit to the south and the Township of Bucke to the north.

Topography

The Cobalt area is characterized by rugged topography with an average elevation of about 1,000 feet above sea level. Regional relief is around 300 feet with local relief up to about 200 feet. Topography is controlled by the bed-rock structure with faulting in the area which has a generally north-west/south-east trend. Crosswise Lake and Kirk Lake appear to lie along a major fault in the area. Cross faults probably also exist throughout this area. The drainage is very disorganized, many depressions being filled with water and poorly connected. The regional bed-rock type appears to be diabase or greenstone. The rugged topography formed by the bed-rock is generally subdued by sand and gravel, cobbles and boulders of glacial, deltaic and lacustrine origin. In the vicinity of mileage 104 north of North Bay at the community of O'Brien, the material is principally relatively thin clay till. In the north Cobalt area, this till is underlain in some places by a few feet of coarser gravelly material. In other places the till rests directly on the bed-rock.

Drainage

(a) North-flowing:

The main streams are Sasaginaga Creek, Mill Creek, Peterson Creek and Farr Creek. Sasaginaga Creek carries drainage from Green Lake, Clear Lake and Sasaginaga Lake, while Mill Creek drains Brief Lake, Short Lake and Cobalt Lake. Cart Lake drains to Peterson Lake which drains via Peterson Creek and flows into Crosswise Lake. Suddie, Goodwin, Nicol, Chown, Kirk and Crosswise Lakes form the chain draining to Farr Creek. At the Community of O'Brien, Sasaginaga Creek and Mill Creek are confluent with Farr Creek which flows a further five miles and empties into Lake Timiskaming.

(b) South-flowing:

Kerr Lake, Glen Lake and Giroux Lake form the chain draining to Giroux Creek and thence to the Montreal River which flows south-east to Lake Timiskaming.

Land Use

The immediate area of the Cobalt Camp is unsuitable for farming on any scale. The area is forested and this, apart from mining, represents virtually the only land use.

The Department of Lands and Forests gives the following ratings:

Agricultural use Capability: 7th rate

Forest use Capability: 5th rate

Wildlife use Capability: 4th rate

Recreational use Capability: 4th rate

Recommended use:

Agriculture 7

Forestry 6

Wildlife 5

Recreation 5

The rating scale is from 1 (excellent) to 7 (unsuitable), but it should be realized that the above uses are to a greater or lesser extent interdependent and an assessment of land use capability should be made accordingly.

SECTION II

THE PRESENT SITUATION

Since the inception of the camp, the accepted method of mill tailings disposal has been to utilize the nearest lake or watercourse. In some cases, the tailings were discharged on to the land without provision of an impoundment system. Tens of millions of tons have been discharged in this manner, without consideration of the consequences and a serious pollution problem has therefore resulted. (Figures II-1, II-2, II-3)

A description of the affected lakes and watercourses follows.

Cobalt Lake

The lake (Figure II-4) is contained between the Ontario Northland Railway tracks on the west and by high ground on the east and south. The lake is approximately 5,000 feet long and not more than 800 feet wide. It is fed at the south-west corner by Short Lake and Brief Lake and empties at the north-east corner into Mill Creek.

The lake has been used extensively for disposal of tailings and is almost completely full. Three dams have been built across the lake:

Dam #1: A wooden dam near the influent behind which Agnico Mines Limited takes water for their tailings reclaim mill.

Dam #2: A rockfill dam almost half-way along the lake.

Dam #3: A rockfill dam about 3,500 feet from the influent end.

Figure II-1



Tailings Deposits in Crosswise Lake

Clearly shown is the erosion of tailings by runoff water.
The tailings are constantly carried into the drainage
watercourse.

Figure II-2



Tailings Deposits in Cart Lake

These tailings have been discharged to the end of the lake farthest from the drainage watercourse. As a result, the quantity of tailings carried away is small during periods of normal runoff.

Note the waste rock and mine water discharge pipe in the foreground, and the two waste rock piles on the opposite shore.

Figure II-3



Tailings Deposits in Cobalt Lake

The water level has been lowered to expose the tailings which Agnico Mines Limited are re-milling. The barge carrying the monitors and pumps is seen at the extreme right of the photograph. The tailings are pumped as a slurry to the mill for processing.

Figure II-4



Cobalt Lake Looking North from Agnico Mines
Limited Tailings Reclaim Mill

The water level has been lowered to allow re-processing of the tailings.

Dam #2 is across the lake at the end of the tailings deposit.

Dam #3 can be seen farther along the lake.

Cobalt Lake Looking South, Showing The Agnico Mines Ltd.
Tailings Reclaim Mill

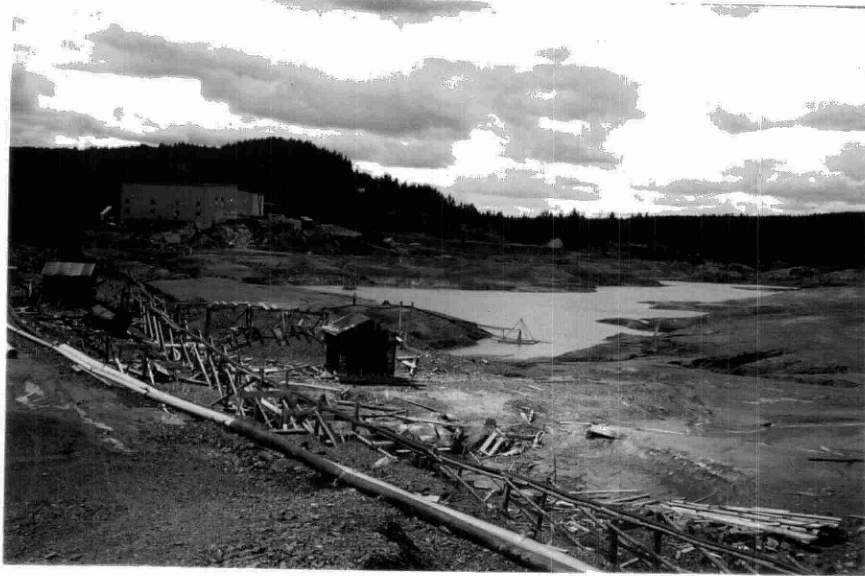


Fig. II-5a

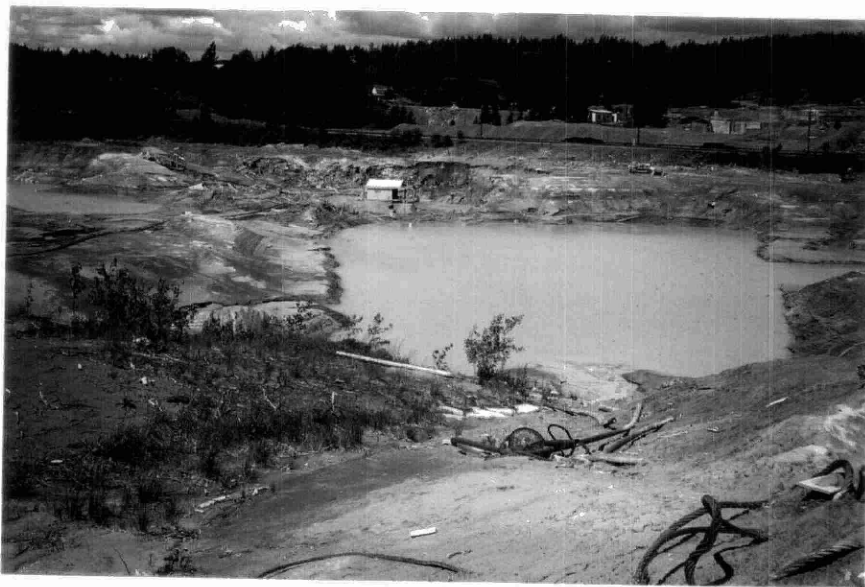


Fig. II-5b

Cobalt Lake Looking West

Agnico Mines Limited has drained the south end of the lake (Figures II-5a, II-5b) and is engaged in re-milling the tailings from the bottom of the lake. The re-milled tailings are being discharged to the north end of the lake along the east side. (Figure II-6)

Agnico Mines Ltd. - Tailings Mill Discharge

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
400912	400586	326	8.0	98.50	2.48

Concentrations in ppm (except pH)

Approximately 1,000,000 tons will be processed during the next five years.

Mill Creek

Mill Creek leaving Cobalt Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
118	11	107	8.3	2.4	0.59
782	11	771	7.8	0.00	0.00
256	19	237	6.5	4.55	2.02
388	54	334	8.3	1.38	1.38

Concentrations in ppm (except pH)

Figure II-6



Cobalt Lake Looking North-West From Dam #3

This shows clearly the build-up of tailings around the discharge point. The trestle and pipe will be extended along the east side of the lake, to ensure that a channel remains open along the west side.

Mill Creek carries the flow from Cobalt Lake and runs in a north-easterly direction along the railway tracks for approximately one mile where it is confluent with Sasaginaga Creek, one-quarter mile west of the Community of O'Brien.

At a point approximately one-half mile from the Town of Cobalt it receives the tailings discharge from the La Rose Mill. From this point to its confluence with Sasaginaga Creek, Mill Creek flows through an area where tailings have been land dumped.

Sasaginaga Creek

The north branch of the creek flows from Sasaginaga Lake and joins the south branch which apparently rises to the north of the Town of Cobalt.

The south branch flows through an area where tailings were land-dumped, to the junction with the north branch. The creek then flows one-half mile east to its confluence with Mill Creek, one quarter mile west of the community of O'Brien. From this point, the watercourse is known as Mill Creek and flows east and south-east for approximately one mile where it joins Farr Creek.

This watercourse carries a high concentration of tailings in suspension. (Figure II-7)

Figure II-7



Mill Creek at Culvert under Highway #11 at the
Community of O'Brien

The high suspended solids content of the stream is easily seen. This is a result of tailings carry-over from Cobalt Lake and from areas where tailings were land dumped in the past. From this point, the creek flows approximately one half ^m mile to its confluence with Farr Creek.

Mill Creek at Highway #11

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
7810	7566	244	7.5	3.42	0.96

Concentrations in ppm (except pH)

Cart Lake

This is a fairly small lake, approximately one-half mile long and not more than 1,000 feet wide. It is not fed by any single discernable watercourse, but empties via a small stream at the north end to Peterson Lake.

The south end of the lake is full of tailings and at present one mill is using this end of the lake as a disposal site. (Figure II-8)

The north end of the lake appears to be fairly clean and it is likely that only during periods of heavy runoff is there any substantial quantity of tailings carried to Peterson Lake.

Peterson Lake

A U-shaped lake with a narrows at the southern end. The western portion of the lake is approximately three-quarters of a mile long by three-tenths of a mile wide, while the eastern part measures approximately one-half mile long by three-tenths of a mile wide.

Figure II-8



Tailings Deposits in Cart Lake

The lake is approximately half full, but the north end is relatively unaffected since the deposits are fairly stable. One mill is discharging tailings to this lake and as the north end becomes full, it is likely that progressively greater quantities of solid material will be carried to Peterson Lake, into which Cart Lake empties.

Peterson Lake is fed by Cart Lake via a small watercourse entering at the south-west corner. It empties from the north-west corner into Peterson Creek.

This lake has not been used for the direct disposal of tailings. Two mines are at present operating on Peterson Lake, but neither mine has a mill and consequently, the only material being disposed of to the lake is waste rock. Ore from both properties is being hauled away to other mills for treatment.

The only source of tailings to this lake is the runoff from Cart Lake and this is not heavy except at peak runoff times.

Flow from Cart Lake to Peterson Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
68	12	56	8.2	1.23	0.31
198	12	186	7.6	0.96	0.96

Concentrations in ppm (except pH)

The water in the lake appears clean and is chemically of fairly good quality, with respect to the tests performed. The lake appears to offer a suitable environment for fish since, at the time of the survey, a large number of minnows of an unidentified type was seen.

Peterson Lake - North East Corner

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
184	3	181	8.2	0.47	0.32

Concentrations in ppm (except pH)

Peterson Creek

This small creek runs north from Peterson Lake for approximately 3,500 feet where it enters a small pond which is used as a supply of mill feed water. From the pond, the creek continues east for some 2,000 feet, through an area which was originally part of Crosswise Lake but is now full of tailings, and joins Farr Creek near the former western shoreline of Crosswise Lake.

Crosswise Lake

This lake is fed from the south east by a chain of lakes, none of which contain tailings and therefore will not be considered here.

Crosswise Lake originally was some two miles long and three-tenths of a mile wide. Tailings were deposited at the northern end of the lake (Figures II-9a, II-9b) which gradually reduced the effective

Crosswise Lake Looking South, Showing Tailings Deposits



Fig. II-9a



Fig. II-9b

Crosswise Lake Looking North, Showing Filled Northern Portion.

length of the lake to its present one mile and one-half. The unaffected portion of the lake appears clean and is of good chemical quality with respect to the tests performed. (Figure II-10)

Crosswise Lake - West shore, south of tailings deposit

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
136	6	130	7.8	0.80	0.06

Concentrations in ppm (except pH)

At the time of the survey, one mill was discharging tailings to the filled portion at the north end, but tailings migration appears to be northward and, unless other mills are re-activated, it is unlikely

Deer Horn Mines Ltd. - O'Brien Mill Discharge

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
99638	99468	170	8.1	27.25	0.15
196048	195738	310	8.1	13.50	0.13

Concentrations in ppm (except pH)

Figure II-10



Crosswise Lake looking south-east, showing clean southern portion of the lake.

The Deer Horn mine is seen on the opposite shore.

that the southern part of the lake will become affected.

The lake drains from the north end to Farr Creek. (Figure II-11)

Farr Creek

This creek drains from the north end of Crosswise Lake

Farr Creek at outlet from Crosswise Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
430	372	58	8.1	2.38	0.14
6136	5796	340	8.0	11.80	0.59

Concentrations in ppm (except pH)

and flows for a distance of some one and one quarter miles through tailings deposits.

Approximately 1,600 feet from Crosswise Lake, the creek is joined by Peterson Creek and a further 1,500 feet downstream by Mill Creek.

The combined streams flow over tailings deposits to a point south of North Cobalt (Figure II-12).

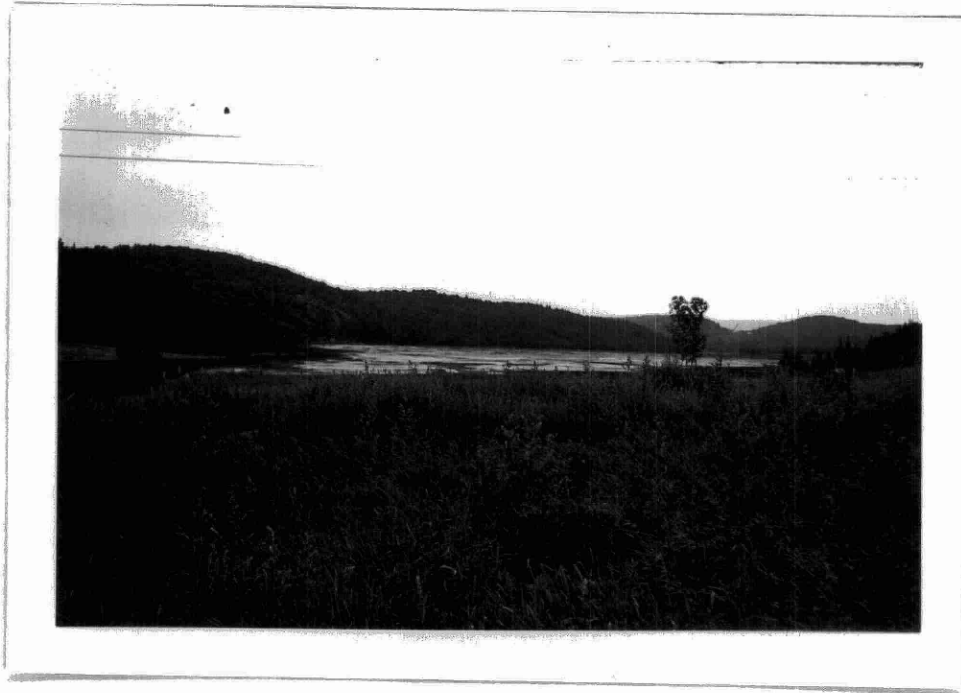
Figure II-11



Farr Creek looking north-east from outflow of Crosswise Lake.

Note the tailings carried by the stream and the tailings deposits on both sides of the watercourse.

Figure II-12



The flood-plain of Farr Creek looking south-west from a point just south of North Cobalt.

Note the spread of tailings across the flood plain.

Note also the physiography of the area. If a dam were constructed near this point to retain tailings, it would appear that the resulting rise in water level would not cause problems in this area.

Farr Creek just south of North Cobalt

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
170	114	56	8.1	0.48	0.48
706	506	200	8.1	2.68	0.80

Concentrations in ppm (except pH)

From this point, the bed of the stream is hard rock, as are the banks.

The banks have a light overburden and are well vegetated.

Farr Creek flows for a further four miles and empties into Lake Timiskaming, one mile south of the Town of Haileybury.

Farr Creek at Lake Timiskaming

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
178	94	84	8.1	0.53	0.53

Concentrations in ppm (except pH)

Kerr Lake

This small lake (Figure II-13), approximately five hundred yards long and two hundred yards wide, is being pumped out to allow mining operations to recommence on the bottom. The water is being discharged to the north-east side of Glen Lake.

Although Kerr Lake has been pumped out and mined in the past, no tailings were deposited there and consequently, the water pumped to Glen Lake is low in suspended solids content. It has, however, a relatively high arsenic content.

Flow from Kerr Lake to Glen Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
170	1	169	7.6	5.15	1.35
266	3	263	7.7	5.90	1.20

Concentrations in ppm (except pH)

The suspended solids and arsenic contents of these samples cannot be correlated. This must be ascribed to analytical error. However, since the test for arsenic is fairly precise and that for suspended solids in this range is not, the arsenic contents will be taken as correct.

Figure II-13



Kerr Lake

This lake is at present being dewatered to allow mining to be carried out. The lake has been pumped out and mined in the past and it is instructive to note the condition in which the area was left when mining operations last ceased. Even in the absence of vegetation on the fairly steep banks, the lake affords a pleasant view for passers-by.

Le Heup Lake

This very small lake drains to the north-west corner of Glen Lake and is used as the discharge point for underground water from Agnico's Nipissing 407 shaft.

Glen Lake

Glen Lake is approximately one-half mile long and not more than three hundred yards wide. It is fed by Le Heup Lake and Kerr Lake and drains from the south-west corner via a small pond to Giroux Lake.

Two mills discharge tailings to the lake which is almost full apart from a small portion at the north end. (Figure II-14)

Glen Lake Silver Mines Ltd. - Tailings Discharge

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
64016	63716	300	8.0	101.0	0.53

Concentrations in ppm (except pH)

The tailings are fairly stable and only during periods of heavy runoff is there any danger of large quantities of solids being carried to Giroux Lake. However, due to the high rate at which Kerr Lake is

Figure II-14



Glen Lake looking east towards the Penn Mill

At this point, the lake is completely full.

The strip of vegetation in the middle of the lake is not growing on tailings, but is a mound of muskeg pushed up by the tailings discharged from both sides of the lake.

being pumped into Glen Lake, the tailings are being disturbed and consequently, the solids and arsenic content of the flow to Giroux Lake has probably been increased. Since no samples were taken prior to the commencement of the dewatering of Kerr Lake, this contention cannot be supported by analytical evidence.

Flow from Glen Lake to Giroux Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
132	49	83	8.1	1.8	0.84
230	14	216	7.9	6.65	1.33

Concentrations in ppm (except pH)

Giroux Lake

This is a fairly large lake, approximately one and one-half miles long by one-half mile wide.

Past and present mining operations do not appear to have affected the quality of the water, especially since no tailings have been deposited in this lake. It was reported by a local resident that

a fish had been caught which was suffering from skin lesions, but from the analysis of the lake water it does not seem likely that the damage to the fish was caused by chemical contamination. Giroux Lake appears to offer a suitable environment for trout and other game fish.

Giroux Lake at North side

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
200	1	199	8.4	0.48	0.48

Concentrations in ppm (except pH)

The lake is fed by Glen Lake at the north-west side and empties into Giroux Creek at the south-west corner.

Giroux Creek

Giroux Creek carries runoff from Giroux Lake and flows south, being joined by several small streams on its five mile course to the Montreal River, into which it flows three-tenths of a mile above Red Pine Rapids.

The creek water appears to be of acceptable chemical quality and trout are regularly introduced by the local Game and Fish Association.

Giroux Creek at outflow from Giroux Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
190	3	187	7.7	0.59	0.59

Concentrations in ppm (except pH)

SECTION III

NATURE, EXTENT AND EFFECTS OF THE PROBLEM

Nature

The natural resources of the Cobalt area include minerals, forests, farmland, lakes and streams, fish and wildlife. It is right and proper that these resources be utilized for the benefit of the community at large. Where various natural resources are closely associated with each other, as in the Cobalt area, it is manifestly impossible to exploit one resource without affecting any other. This is particularly true of the mining industry.

In an ore body, the values may be concentrated in veins which may assay from 100 to 10,000 oz. per ton, or in the wall rock which may run from 8 - 40 oz. per ton. Veins are, therefore, very rich, but may be from only a crack to several inches wide. It is evident, therefore, that no matter how the values are found, great quantities of waste material must be mined to obtain these values. In the Cobalt camp, the rock is very stable and the mines are fairly shallow, therefore back-filling is not required. Consequently, virtually all rock broken is brought to surface and remains there, whether or not further processing takes place. It is the final disposition of this waste material, whether waste rock from the mine or tailings from the mill, which requires large tracts of land and water and disrupts the normal equilibrium of the natural resources of the area. (Figure III-1)

Figure III-1



A Mining Landscape.

In Cobalt, the adverse effects of mining operations have been confined largely to water resources. Lakes have been used as disposal sites for mill tailings and as a result, some lakes are full or partly full of settled solid material (Figure III-2). This of itself is not the present day problem. Rather it is the carrying away (Figure III-3) of settled material by runoff water (springs, rainfall, etc.) into the drainage watercourses, which may lead to the pollution of presently unaffected waters. It should also be borne in mind that the discharge from a mill is partly "colloidal" in nature and is difficult to settle, especially in conditions of even slight flow or turbulence. Tailings may therefore be carried long distances from the original discharge point and exert their polluttional effects over a wide area (Figure III-4). It is this progressive pollution which is the major source of concern.

Suspended solids and arsenic are the most important contaminants, other metals and pH being within acceptable concentrations. Examination of raw tailings analyses shows that the arsenic content is virtually completely in the insoluble state and is thus related to the suspended solids content. Removal of the suspended solids will effect a marked reduction in the polluttional characteristics of mill tailings. Various possible means of preventing migration of tailings, thereby reducing the polluttional load to lakes and watercourses not presently affected to a great extent, are discussed in another section of this report.

Figure III-2



Glen Lake looking south from Glen Lake Silver Mines Ltd.
property.

The tailings have covered the road at this point.

Figure III-3



Crosswise Lake showing erosion and washing out of tailings.

Figure III-4



Farr Creek at North Cobalt

Representative tailings discharges from
various mills in the Cobalt Area

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
99638	99468	170	8.1	27.25	0.15
196048	195738	310	8.1	13.50	0.13
64016	63716	300	8.0	101.00	0.53
400912	400586	326	8.0	98.50	2.48
132200	131960	240	8.4	-	0.34

Concentrations in ppm (except pH)

The nature of the problem is, therefore, quite straightforward. Past and present disposal of mill tailings in an unsatisfactory manner allows solid material to migrate from the original discharge point and exert a polluttional effect over a wide area. This is a perfect example of progressive pollution.

Extent

Although the tailings are fairly localized in several areas, the polluttional effects of the deposits extend over a large area, due to the transport of tailings away from the disposal points by local watercourses.

The tailings deposits occupy about 300 acres and include two lakes filled and two lakes half filled. Depth of tailings varies from a few inches to around fifty feet.

The area affected, however, is much larger, extending from the Montreal River in the south to Haileybury in the north, and from Cobalt east to Crosswise Lake. At the present time, there is no evidence that the Montreal River is being affected, although arsenic is present in Giroux Creek.

Giroux Creek at outflow from Giroux Lake
Five miles from Montreal River

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
190	3	187	7.7	0.59	0.59

Concentrations in ppm (except pH)

Lake Timiskaming, into which Farr Creek empties, is being affected by suspended solids and arsenic. However, since this lake is an extremely large body of water, it is doubtful if the quantities of solid material and arsenic carried by Farr Creek seriously affect the lake. Samples of the lake water would be required to determine this.

Farr Creek at Lake Timiskaming

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
178	94	84	8.1	0.53	0.53

Concentrations in ppm (except pH)

Effects

As already stated, the major contaminants are solids and arsenic.

The polluttional effects of solids include difficulties with water purification, silting up of stream beds, injury to the habitat of fish and other aquatic life, and aesthetic effects rendering the water unfit, or at least undesirable, for recreational purposes.

Pollution by arsenic is serious and the spread of this toxic element by water must be regarded with much concern. The extreme toxicity of arsenic is well-known and a dose as small as 130 milligrams has proved fatal to humans. Furthermore, arsenic is a cumulative poison and repeated small doses may become fatal. The United States Public Health Service in its Drinking Water Standards, 1962, gives a maximum

permissible concentration for arsenic of 0.05 milligrams per litre in drinking water supplies, with a recommended limiting concentration of 0.01 milligrams per litre. Very small concentrations in water are harmful (or fatal) to fish and other aquatic life. It is obvious that the presence of arsenic in water, even in small concentrations, renders that water unfit for most uses.

SECTION IV
THE SOLUTION

If it is accepted that the exploitation of mineral resources is important not only to the Cobalt area but to the economy of the country as a whole, then a certain degree of pollution must be accepted, since it appears that in the Cobalt area it is economically not feasible to eliminate pollution entirely. However, since nothing is more important to every facet of the growth of this country than "clean" water, progressive pollution cannot and must not be allowed to continue, for it is this which represents the greatest threat to water resources as a whole. Progressive pollution must be eliminated and residual pollution must be minimized.

Before any discourse on the possible means of pollution abatement is tendered, the question of whether or not lakes may properly be used for mill tailings disposal must be answered. The view that lakes may not be used as disposal sites is, in this case, purely idealistic, since tailings have been discharged in this way for more than sixty years. Any discussion of the merits of this view is academic and has no place in this report.

The opposite view, that lakes may be used unconditionally as disposal sites, is irresponsible and has led to the present unsatisfactory situation in the Cobalt area.

In view of the fact that lakes have been and are being used for disposal of mill tailings, the realistic answer to the question is

that steps must be taken to minimize pollution resulting from past operations and that controls and conditions must be applied to present and future use of the lakes as tailings disposal sites. However, controls and conditions do not represent the whole key to the solution of present and continuing pollution problems. Perhaps more important is recognition of the fact that where lakes are used to contain mill tailings, the essence of the operation is containment. That is, rather than merely convenient disposal sites, lakes used in this way should be effective impoundment areas. Under no circumstances should this view be construed as a licence to pollute. It is not. Rather, it is the acceptance of resources management, of striking a balance between economic exploitation of one resource and the detrimental effects of such exploitation on other resources.

That the mining industry in the Cobalt area has not recognized the need for a programme of resources management is patently obvious. However, to say that tailings have been discharged haphazardly is not accurate. On the contrary, pains were taken to ensure that tailings were laundered directly to the nearest lake or watercourse. This is still true of present operations. (Figure IV-1)

At issue here is not the fact that lakes and streams were and are presently being used to dispose of mill tailings, but the manner in which they were and are being used. Absolutely indefensible is the practice of discharging tailings at or near the outflow end of a lake,

Figure IV-1



Deer Horn (O'Brien) Mill discharge to Crosswise Lake

especially a lake which is fed by a chain of lakes and has a constant flow-through, thereby allowing little or no retention time with consequent carry-over of tailings to the drainage watercourse.

Farr Creek - Flow from Crosswise Lake

SOLIDS			pH	ARSENIC	
Tot	Susp	Diss		Tot	Sol
430	372	58	8.1	2.38	0.14
6136	5796	340	8.0	11.8	0.59

Concentrations in ppm (except pH)

Also to be condemned is the attitude of "laissez-faire" with respect to the continued discharge of tailings to a lake which has become full.

Solving the Problem

The solution to a problem of a nature and scale such as that existing in the Cobalt area will only be found through a concerted effort by Government and industry. The responsibilities of various departments of Government and of industry must be clearly delineated and accepted. These responsibilities include political, legislative, economic, social and health factors, all of which must be considered in conjunction with the responsibility for the technological solution to the problem. That

the purely physical solution is straightforward, although not simple, and certainly within our technological capabilities, is beyond doubt. However, the present work was carried out as a preliminary assessment of the situation and, therefore, information was not obtained in great enough depth or diversity to suggest a complete solution. However, the following points should be considered:

- (1) The purpose of any remedial action should be to eliminate progressive pollution, minimize residual pollution and, within reason, rehabilitate water resources and land areas.
- (2) Tailings carried to Lake Timiskaming by Farr Creek may possibly be retained by construction of a dam at a suitable location south of the Community of North Cobalt (Figure IV-2). If further studies indicate that such a dam would successfully retain tailings, it would represent the solution to the major problem since the tailings carried by Sasaginaga Creek, Mill Creek and Farr Creek would be impounded. However, this would involve a constant build-up of tailings behind the dam which if not removed would probably in the future render the dam useless. In addition, the effects

Figure IV-2



Farr Creek just south of North Cobalt

Note the steep banks and the hardrock bed. This appears to be the most suitable point for construction of a dam to impound the tailings carried by Farr Creek - Mill Creek.

The stream is obviously heavily polluted at this point, only three miles from Lake Timiskaming.

of the rise in water level in the system would require to be carefully considered.

- (3) The flow through Crosswise Lake, Cobalt Lake, Sasaginaga - Mill Creek flood plain and Farr Creek flood plain may be piped or culverted through the tailings deposits, but this may be impractical on economic grounds. Also, the problem of runoff water from the immediate area of these lakes and creeks would still exist.
- (4) Instead of culverts, open ditches could be constructed and faced with a material which would not wash away. However, decant structures would be required to ensure that runoff would not carry tailings into the open ditches.
- (5) Egress of tailings from Glen Lake to Giroux Lake and from Cart Lake to Peterson Lake should be prevented, perhaps by means of dams.
- (6) A programme of re-vegetation of tailings areas should be actively pursued.
- (7) In future, tailings should not be deposited in any lake or watercourse not already affected.

- (8) The tailings disposal practices of the presently operating mines should be examined with a view to improving tailings impoundment.

The above points are not to be construed as recommendations, but only as suggestions as a basis for further study of the area.

SECTION V
RECOMMENDATIONS

As already stated, the purely physical solution to the problem will be straightforward. However, further study of the area is required before any specific pollution control measures can be decided upon.

It is recommended, therefore, that:

- (1) The responsibilities of the various departments of Government and of the operating mining companies in the area involved in finding a solution to the problem be clearly delineated.
- (2) Upon resolution of recommendation (1), the responsible Government departments and/or industries should investigate the situation in sufficient detail to enable pollution control measures to be recommended.
- (3) A co-ordinating committee composed of representatives of the various Government departments and/or mining companies be formed to carry out the recommended pollution control measures.

ACKNOWLEDGMENTS

The assistance of staff of the Department of Lands and Forests and the Department of Mines is gratefully acknowledged. Particular thanks is due to Mr. J. K. Hurst, District Engineer of Mines, Kirkland Lake, for his assistance in the field and his data pertaining to the mines of the Cobalt area.

The author also acknowledges the co-operation afforded the members of the survey party by the personnel of the mines involved in this investigation.

APPENDIX 1

SILVER

The metal silver has been known and valued since the earliest recorded times. It was used as a medium of exchange, as a material for the manufacture of utensils, and as ornamentation, publicly displaying the wealth and power of its owner. More recently, it has found a host of industrial uses and is now an extremely useful mineral.

Silver occurs widely all over the world and has been produced in most countries at some time. In 1966, Canada was among the top four producers of the metal:

<u>Country</u>	<u>Production (Ounces)</u>
U.S.A.	42,484,900
Mexico	41,983,529
Peru	32,841,241
Canada	32,824,514

It is estimated that Canadian production in 1967 will be in excess of 40 million ounces.

It is interesting to note that 80% of the silver produced in Canada is obtained as a by-product of base metal and gold mining, and only 20% from silver mining per se. Of the silver camps, Cobalt has been indisputably the greatest producer, with an output to date of more than 500,000,000 troy ounces of the precious metal.

Economic Consideration

The monetary system of the country is supported by gold

reserves, not by silver, and for this reason silver is not a prerequisite for a strong currency. If silver production in this country ceased, the value of the dollar would not be affected, but since silver is an extremely useful and valuable metal, foreign exchange would be lost by the necessary import of the material from other countries.

The price of most commodities is usually governed by considerations of supply and demand, but until recently, relying on large reserves of silver, the United States has sold the metal at the artificially low price of \$1.29 per ounce. At this price, the value of the metal of the dollar piece was one dollar. Now that the price of silver has increased by some 45%, the silver dollar is worth considerably more than its nominal value. The "silver" coinage in this country and in the United States will therefore no longer be silver, but an alloy of nickel.

With the elimination of silver coins the only uses for the metal on this Continent will be industrial. The popularisation and growing uses of photography, the expansion of the electronics and other industries using silver, and an increasing demand for silver for domestic purposes will inevitably lead to higher prices for the metal which will result in exploitation of presently uneconomic known ore reserves and stimulate exploration and development of new mines. Until an acceptable substitute for silver is found, this trend may be expected to continue.

Practical Aspects

Silver has several attributes which render it extremely valuable industrially. These include conductance, malleability, ductility, aesthetically desirable appearance of the metal and the photosensitivity and chemical reagent usefulness of certain silver compounds.

The largest user of silver is the photographic industry, but electronics and electrical industries also use large quantities of the metal. In addition, large amounts are used in jewellery, silver ornaments and curios and domestic utensils. Almost every other industry will have occasion to utilize silver, either in specialized processes (electroplating, etc.) or in the form of analytical reagents.

Industrial consumption of silver is rising steadily and demand exceeds supply. From 1956 - 1960 in the United States, an average of 96,780,000 troy ounces were used industrially per annum and by 1965 consumption had risen to 137,000,000 troy ounces. At the present time, it is difficult to conceive of a substitute for this singularly useful metal.

Occurrence

In the Cobalt area, the silver deposits are associated with a sheet of diabase around 1,000 feet thick which penetrates beds of altered (metamorphosed) sedimentary rocks consisting of conglomerate,

quartzite and greywacke. The sediments rest on the Keewatin Basalt which is also penetrated by the diabase sheet. The deposits consist of narrow, generally vertical veins (3 - 4 inches wide on average) cutting the sediments, diabase and basalt. The silver is found chiefly native, in veins mostly of calcite, but also of dolomite. In addition, the silver is associated with arsenides and sulpharsenides of cobalt, nickel and iron. Host rocks (sediments of the Coleman Formation - formerly called Gowganda Formation) are conglomerate, diabase and lavas.

The mineralogy is very complex, but some of the more important compounds are as follows:

Silver bearing:	dyscrasite	Ag_6Sb_2	
	argentite	Ag_2S	
	pyrargyrite	Ag_3SbS_3	} ruby silvers
	proustite	Ag_3AsS_3	
Cobalt bearing:	Smaltite	CoAs_2	
	Cobaltite	CoAsS	

The silver occurs 96% native or from 85% to 90% purity. The main impurity is antimony, with smaller amounts of arsenic and mercury. Bismuth and graphite occur native and materials containing lead, iron, copper, nickel and phosphate are also found. Vein materials are calcite, dolomite, aragonite, smaltite, niccolite, quartz, barite and fluorite.

Veins are very rich and range from 100 to 10,000 and more ounces per ton. Wall rock may contain from 8 to 30 ounces per ton. Most low

CONCENTRATING MILL FLOW SHEET

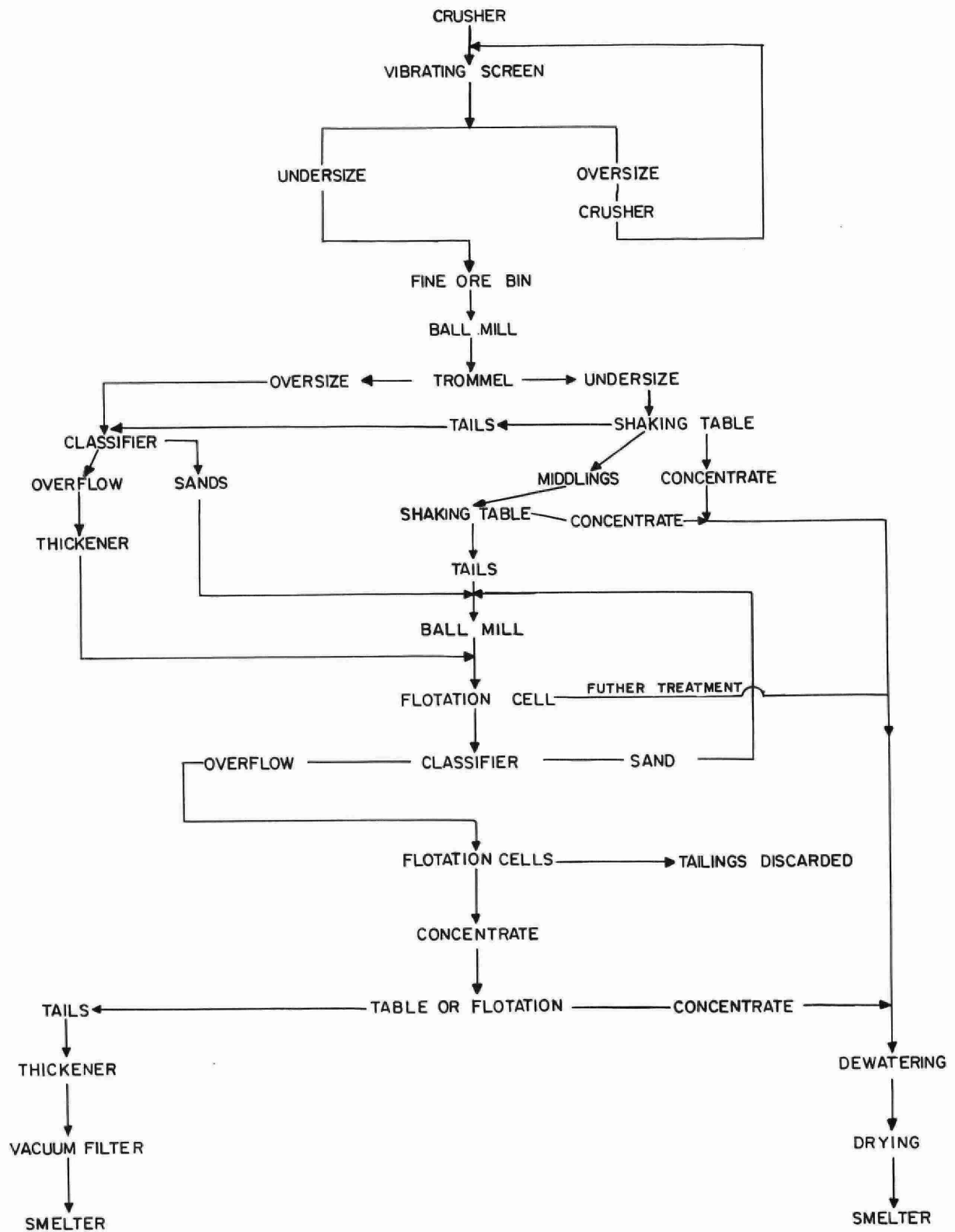


Figure 1-1

grade ore occurs in rocks of the Cobalt Series (sediments). This is a shallow zone and most ore is found at less than 400 feet, with a greatest depth of around 1,000 feet.

Extraction

(a) Mining

Due to the shallow workings, the stability of the rock and the narrow, regular ore bodies, shrinkage stoping is the normally employed mining method in the area.

A shrinkage stope is an excavation in a mine where the ore is drilled, blasted and removed through chutes to a haulage level below. After each blast, sufficient ore is taken from the chutes to make room for drilling and blasting the next section. When the stope is completed, it is full of broken ore and this is classed as broken ore reserve. In the Cobalt camp, after removal of broken ore from a stope, no back-filling is done and consequently, all material brought to surface remains there. When the ore is brought from the mine, it may either be stockpiled or sent directly to the mill, depending on requirements.

(b) Milling

(1) Process: The run of mine ore is fed from a hopper to a series of crushers (Figure 1-1) which reduce the size

(1) Process (Cont'd)

of the pieces to that which can be handled in the mills. After crushing, the ore is screened, the oversize being further crushed and returned to the screen. From the screen, the ore is passed to the fine ore bin. From here, the material is passed to the ball mills where it is ground to a size which will ensure the maximum liberation of values with the minimum production of slimes. From the ball mill, the material is classified, the undersize going to a shaking table which produces a concentrate, middlings and tailings. The oversize joins the tails from the shaking table and is further classified, the overflow being thickened and sent to primary flotation, while the underflow is sent to a further ball mill. The middlings from the shaking table are again tabled, producing a concentrate and tails. This concentrate joins the concentrate from the first tabling and is sent to dewatering. The tails from the second table join the underflow from the second classifier in a ball mill, from which the ore joins the thickened overflow from the second classifier in a primary flotation cell. From the cell, the concentrate goes to further processing, while the tails are classified. The underflow from the classifier, is returned to the ball mill and the

(1) Process (Cont'd)

overflow is passed to further flotation. From this flotation operation the tailings are discarded as waste, while the float is further concentrated by tabling or flotation. In either case, the concentrate joins concentrates from previous operations and is dewatered, dried and sent to the smelter. The tailings from the final flotation or tabling are thickened, vacuum filtered and sent to the smelter.

It should be emphasized that the procedure described above is a general one and will be altered somewhat according to the particular requirements of a specific mill. However, the principle remains the same.

- (2) Principles: Ore raised from a mine may contain only a small percentage of the desired mineral. It is necessary to separate the valuable component from the undesirable material and this is done at or near the mine site (generally only partial separation) to produce concentrates of valuable minerals and tailings composed of less valuable material and waste (gangue). This procedure is known as mineral dressing. At the present time, froth flotation is the most widely used method of mineral dressing.

Froth flotation as a separation process, is usually applied to metallic ores which are ground finer than 50

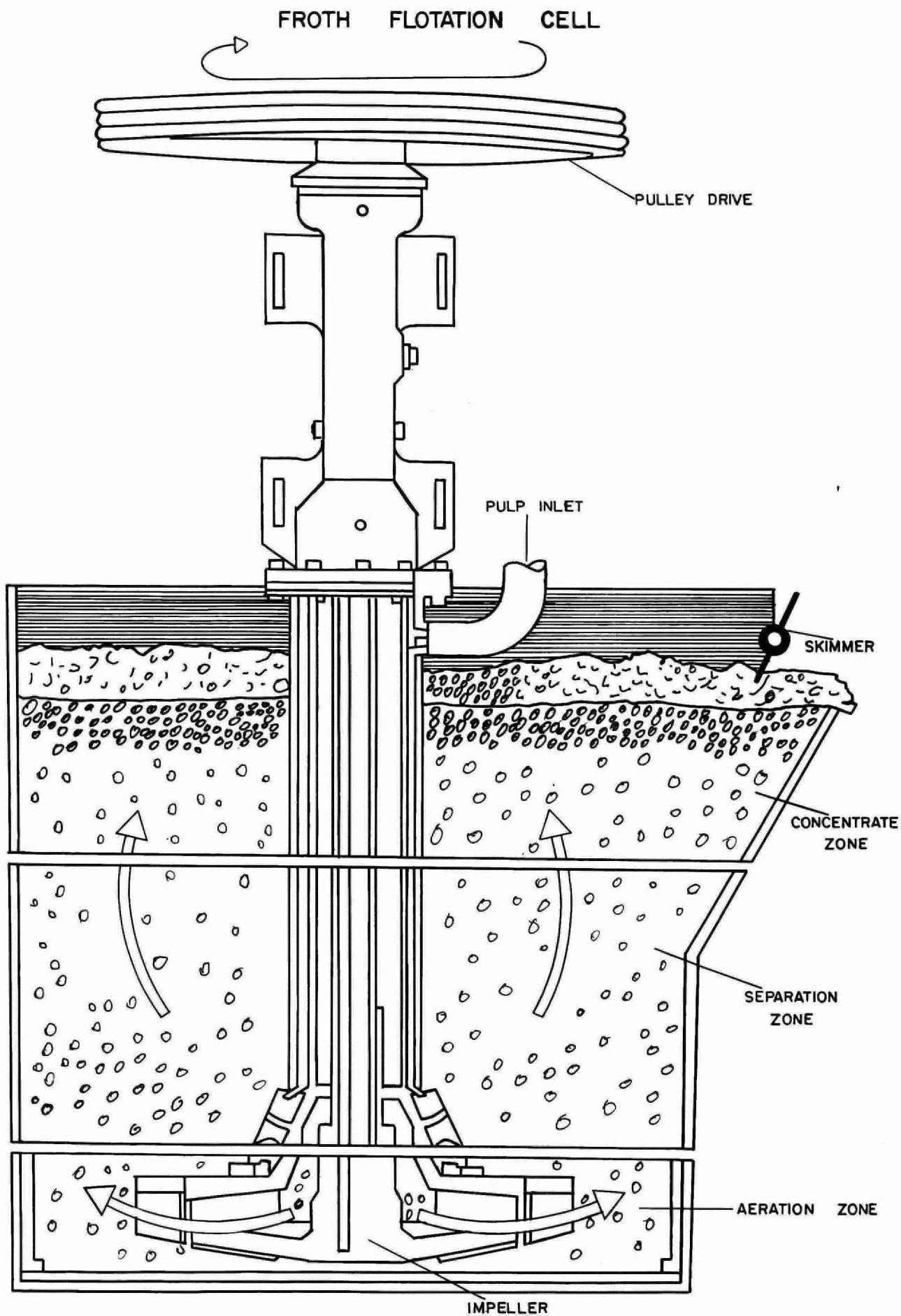


Figure 1-2

(2) Principles (Cont'd)

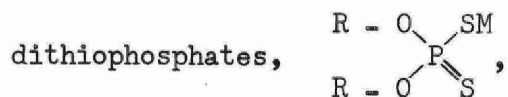
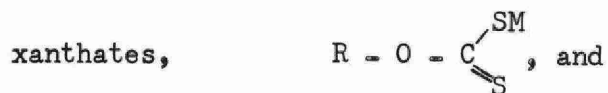
mesh and generally much finer. The fineness of grind required is determined by the particle size at which valuable materials are liberated from waste particles. In any case, a grind coarser than 50 mesh generally cannot be used since satisfactory mixing and suspension cannot be attained in the flotation cell.

The finely ground ore is suspended in water at a pulp density usually from 15 - 40 per cent (weight) solids and fed to the flotation cell (Figure 1-2), where it is kept in suspension by stirring and/or air agitation. Chemicals called promoters (collectors) are added which adhere to the surfaces of specific minerals and render them hydrophobic and aerophilic. A frother is added and with vigorous agitation and aeration, a layer of froth forms at the liquid surface. The minerals which have been rendered aerophilic by the promoter(s) become attached to air bubbles and rise to the surface where they collect in the froth and are removed by skimmers. By addition of depressants, or by leaving their surfaces unchanged by promoter addition, minerals not wanted in the froth are rendered non-floatable. The valuable mineral concentrate may be either the skimmed off froth or the underflow product. In the case of silver

(2) Principles (Cont'd)

ores, the silver collects in the froth, while the waste material comprises the underflow.

Chemicals used in the process vary according to the value to be concentrated. For silver, the most widely used promoters (collectors) are:



where M is sodium or Potassium and R is an alkyl group of two to six carbon atoms. It is used in quantities of from 0.01 to 0.4 lbs/ton. Methylisobutyl carbinol (MIBC) is a widely used frother, as are other aliphatic alcohols, and is required in proportions of 0.01 to 0.2 lb/ton.

Modifying agents are used in widely varying concentrations according to the specific requirement. These agents include activators, pH regulators, deflocculants and depressants.

APPENDIX 2
THE COBALT CAMP

History

In the fall of 1903, Ernest Darragh discovered the first silver found in the area. With his partner, McKinley, he was looking for timber suitable for railway ties, for which they had a contract with the Temiskaming and Northern Ontario Railway to supply. While searching along the shore at the extreme south end of Cobalt Lake, they noticed a strange colouration of the ground and upon investigation, discovered flakes of a bright metal in the gravel. Thus the first silver was found. A little later, Fred La Rose, a blacksmith, found silver near his shop, a little more than a mile to the north of the original discovery. (Figure 2-1)

Two explanations of the origin of the name of the camp are current. One, probably apocryphal, is that the early assays showed a preponderance of the metal cobalt and the camp which sprang up almost overnight was thus named for the then rare element. More mundane, but more likely is the explanation that the Provincial Geologist, Dr. W. G. Miller, requested that the railway station be named Cobalt, a more distinctive name than the original Long Lake. Whatever the origin of the name, it was soon to be known everywhere as that of the "World's Richest Silver Camp".

Ore was first shipped in the summer of 1904 and during that year, some 158 tons produced a revenue of more than 136,000 dollars.

Figure 2-1



The La Rose Mine and Mill

Silver was found here in 1903 and the mine became a fabulous producer, with one of the richest veins in the history of the camp.

During the next four years the camp grew and in 1909 the thirty thousand tons of ore shipped realized almost 12,500,000 dollars. In 1911, 31,508,000 ounces of silver worth sixteen million dollars were produced from only 17,000 tons of ore.

The following table shows the number of producing mines during the period 1904-1922:

1904 - 4	1914 - 32
1905 - 16	1915 - 24
1906 - 17	1916 - 28
1907 - 28	1917 - 28
1908 - 30	1918 - 38
1909 - 31	1919 - 33
1910 - 41	1920 - 35
1911 - 34	1921 - 28
1912 - 30	1922 - 22
1913 - 35	

In 1910, there were fourteen mills producing concentrates for the smelters.

During the early years of the camp, the values found were so high that it was properly described as a bonanza. However, this led some people to declare that it could not last - that "the veins were too narrow and too rich to indicate depth and extent". That this theory

was fallacious is clearly demonstrated by the remarkable constancy of production during the twenty years following the original strike.

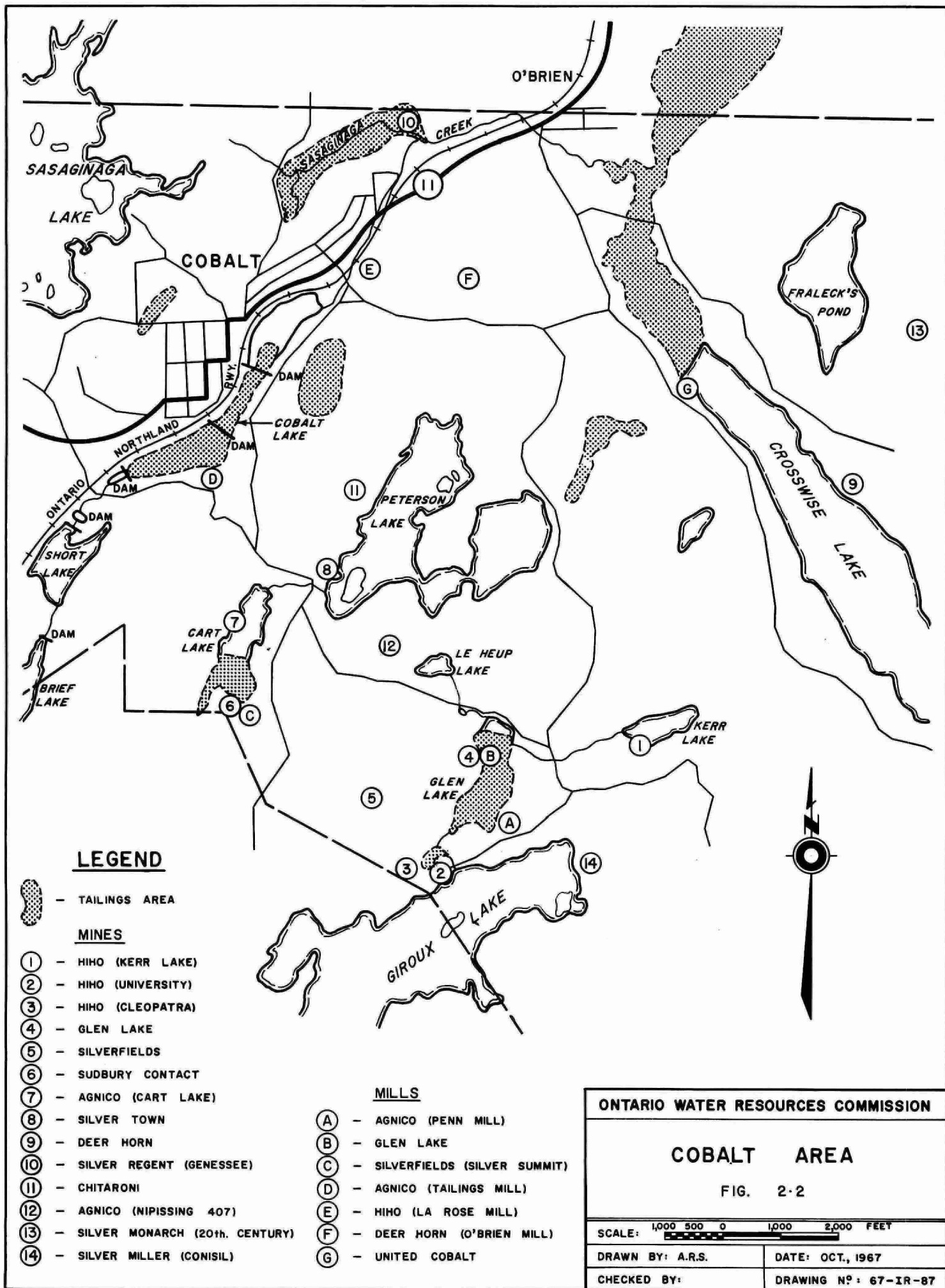
From the early twenties, the fortunes of the camp waned somewhat and prospects were certainly not enhanced by a world-wide economic depression and the Second World War. The camp remained in the doldrums until the middle nineteen-fifties when an increase in the price of silver and the more stable economic atmosphere resulted in an increase in activity.

The Camp Today

At the present time, the camp has lost much of the fame of the early nineteen hundreds, but is a steady producer.

At the start of 1967, twelve properties were producing and milling was being carried out at four sites. Later in the year, two more mills commenced operations. Ore from the following mines is milled in the corresponding mills (Figure 2-2):

<u>Name of Mine</u>		<u>Name of Mill</u>
Agnico	- Nipissing 407	Penn (Agnico)
Agnico	- Tailings Reclaim	Cobalt Lake Tailings Mill (Agnico)
Chitaroni	- (Agnico) Little Nipissing	Penn*
Deer Horn		O'Brien (Deer Horn)
Glen Lake	- Bailey	Glen Lake (Glen Lake)



<u>Name of Mine</u>		<u>Name of Mill</u>
Hiho	- University #3	Glen Lake+
Hiho	- Cleopatra Main	Glen Lake+
Hiho	- Kerr Lake and Crown Reserve	La Rose (Silver Miller)#
Silverfields	- Alexandra	Silver Summit (Silverfields)
Silver Miller		No milling - stockpiled
Silver Town	- Peterson Lake	O'Brien*
Sudbury Contact	- Provincial	Penn*

* Custom milling.

+ Glen Lake Silver Mines Limited and Hiho Silver Mines Limited are parts of the same group.

Hiho Silver Mines Limited is purchasing the La Rose Mill from Silver Town Mines Limited in order to mill ore from the old stockpile at Kerr Lake.

The La Rose Mill and the Agnico Tailings Mill came into operation during 1967. It should be noted that the Penn Mill and the Tailings Mill are operated alternately (Tailings Mill in summer, Penn Mill in winter), the ore from the Nipissing 407 shaft being stockpiled during the summer.

Exploration and development is underway at several properties, which may lead to a further upsurge in the fortunes of the camp and

consequently increased activity. The producing companies, their properties and activities during 1966 are summarized below:

Agnico Mines Limited

Cobalt Consolidated Mining Corporation Limited was incorporated in January 1953; in October 1957 the name was changed to Agnico Mines Limited with an authorized capitalization of 5,000,000 shares of \$1 par value, of which 3,434,327 shares have been issued. The directors and officers are: N. B. Sheriff, president and director; P. Penna, vice-president and managing director; B. Kraft, secretary-treasurer and director; J. Osheroff and Milton Klyman, directors. The head office is at Suite 1101, 365 Bay Street, Toronto 1; the mine address is Box 140, Cobalt.

The company acquired properties formerly held by Silanco Mining and Refining Company Limited; Cobalt Lode Silver Mines Limited; Penn-Cobalt Silver Mines Limited; Gilgreer Mines Limited; Keylobe Cobalt Silver Mines Limited; Hellens Mining and Reduction Company Limited; and others in the Cobalt, South Lorrain, and Gowganda areas, District of Timiskaming. A group of mines in Coleman township, including the Beaver and Temiskaming mines, was acquired in 1955, and the O'Brien mine in 1958.

Agaunico Property

The Agaunico property is located in Bucke township, District of Timiskaming. In 1966 two diamond-drillholes totalling 1,220 feet were completed from surface.

Cart Lake Property

The Cart Lake property comprises claim RL 406, approximately 151 acres, and claim RL 404, 168 acres in Coleman township, District of Timiskaming.

Operations progressed from January to December 1966. Development work consisted of 573 feet of drifting and 375 feet of raising. Total development footage to 31 December 1966 on the 100- and 185-foot levels was as follows: 1,359 feet of drifts; 250 feet of crosscuts; and 531 feet of raises. Some 9 diamond-drillholes, totalling 2,552 feet, were completed from surface, and 33 holes, totalling 6,341 feet, were completed from underground.

Some 6,096 tons of ore was hoisted and treated in the Penn Mill.

Lode and Christopher Properties

The Christopher mine adjoins the south boundary of the Cobalt Lode mine, in lot 2, concession III, Coleman township; the properties comprise claims 106, 1970, 9, 535 and 1923. Operations progressed from January to April 1966.

The Cobalt Lode and Christopher shafts are connected on the 400-foot level and the nearby Brady Lake No. 4 shaft, leased from Silver-Miller, connects with the Cobalt Lode shaft on the 600-foot level. Mining operations in 1966 were on the Christopher property.

There was no development work completed in 1966. Total development footage to 31 December 1966 was as follows: 16,242 feet of drifts, 5,054 feet of crosscuts, 14,932 feet of raises on the Christopher property; 10,255 feet of drifts, 4,955 feet of crosscuts, 6,183 feet of raises on the Lode property.

A total of 2,953 tons of ore was hoisted from the Christopher property and trucked to the mill.

O'Brien Property

Nipissing-O'Brien Mines Limited was incorporated in January 1952. The company acquired the properties of M. J. O'Brien Limited, and Nipissing Mines Company Limited in concessions V and VI, Coleman township, District of Timiskaming.

Nipissing-O'Brien Mines Limited operated the property until June 1958, when claim RL 403 comprising 152.6 acres was purchased by Agnico Mines Limited. Mining operations continued at the O'Brien mine from January to July 1966.

Development work consisted of 121 feet of drifting, 90 feet of sub-drifting, and 180 feet of raising. Total development footage to

31 December 1966 was as follows: 11,241 feet of drifts; 5,738 feet of sub-drifts; 2,314 feet of crosscuts; 12,118 feet of raises. Some 48 diamond-drillholes totalling 6,853 feet were completed from underground.

Total of 5,258 tons of ore was hoisted and milled.

Nipissing 407 Property

The property comprises claim RL 407, 408, 92 and 110 located in Coleman township, where the vertical, two compartment 407 shaft has a depth of 460 feet below the collar. The shaft, located in high ground, is north of the Silverfields property and about 500 feet from the highway passing the Glen Lake silver property. There is also the vertical, two compartment No. 150 shaft some 325 feet deep located on claim RL 407.

Operations progressed throughout 1966. Development footage consisted of 1,855 feet of drifting, 830 feet of sub-drifting, 860 feet of crosscutting and 730 feet of raising. Total development footage to 31 December 1966 was as follows: 4,899 feet of drifts; 948 feet of sub-drifts; 6,573 feet of crosscuts; 2,288 feet of raises. Some 264 diamond-drillholes, totalling 18,754 feet were completed from underground in 1966.

Foster Property

The Foster property comprises claim No. 66 located in Coleman township, District of Timiskaming.

Exploratory work in 1966 consisted of the completion of five diamond-drillholes totalling 2,466 feet from surface.

Penn Mill

The Penn Mill operated from 3 January to 30 December, 1966.

Production

The following is taken from the company annual report for the year ending 31 December, 1966.

The main source of production during 1966 was from 407 shaft which is now producing ore from three levels. Stoping on the third level has produced very rich ore from veins of limited vertical dimensions. The Cart Lake No. 2 shaft produced a modest tonnage of ore up until the end of the year. The Christopher and O'Brien properties produced a small tonnage of ore before being closed down early in the year.

The average monthly production for 1966 was 66,845 ounces. The decrease from the previous year is a result of reduced production due to the phasing out of two producing properties.

The following is a comparative summary of the main production items:

		1966	1965
Silver produced	oz.	802,151	1,101,932
Cobalt produced	lb.	71,779	93,257
Gross value of metals sold	\$	1,083,288	1,486,633
Gross value per ounce of contained silver		1.35	1.35
Total milled from company properties	tons	47,550	70,975
Custom ore milled	tons	1,790	38,051
Total milled	tons	49,340	109,026
Total hoisted	tons	46,848	74,198
Calculated head silver	oz./ton	17.69	16.40
Recovery silver	oz./ton	16.87	15.53
Extraction efficiency	percent	95.36	94.64

Tailings Reclamation Project

A mill located on the south shore of Cobalt Lake has been rehabilitated and equipped to recover silver from an estimated one million tons of tailings averaging about 4 ounces per ton.

A barge on the lake is used to pump the tailings to the mill at a rate of 1,000 tons per day where they are processed by grinding and flotation.

A satisfactory test run was made in October resulting in an indicated recovery of 75.7 percent.

It is planned to use the personnel from the Penn Mill to operate the tailings mill from May to October, after which time freezing conditions make it difficult to pump tailings. The Penn Mill will run during the winter months on a higher tonnage basis, supplied by ore stockpiled during the summer months plus current mine production. This will result in a more efficient operation.

The average number of employees at all operations was 123 - 57 underground and 66 on surface. G. W. Kirk is the mine manager.

Production and Process Data

Tailings Reclaim Mill

Mine Production (Tons per day)	-
Mill Production (Tons per day)	1,000
Quantity of Tailings (Tons per day)	975
Chemical process reagents used and quantities	Xanthate - 0.3 lb./ton Frother - 0.2 lb./ton
Volume of water pumped to Mill	550,000 gpd
Source of Mill water	Outlet from Short Lake
Point of Discharge of Tailings	North End of Cobalt Lake
Point of Discharge of Mine Water	-
Approximate ore assay	4 ounces per ton silver

Production and Process DataTailings Reclaim Mill

Operating Schedule:

No. of Employees - 67
No. of Shifts - 10
Days per week - 5
Hours per day - 16

Production and Process DataPenn Mill

Mine Production (Tons per day)

250

Mill Production (Tons per day)

360

Quantity of Tailings (Tons per day)

355

Chemical process reagents
used and quantitiesXanthate - 0.4 lb./ton
Frother - 0.02 lb./ton

Supplier of Chemical Reagents

Cyanamid

Volume of water pumped to Mill

150,000 gpd

Source of Mill water

Giroux Lake

Point of Discharge of Tailings

Glen Lake

Point of Discharge of Mine Water

Le Heup Lake

Approximate ore assay

20 ounces per ton silver

Operating Schedule:

No. of Employees - 20
No. of Shifts - 18
Days per week - 6
Hours per day - 24

DEER HORN MINES LIMITED

Deer Horn Mines Limited was incorporated in December 1950, with an authorized capitalization of 5,000,000 shares of \$1 par value, of which 4,935,005 shares have been issued. The directors and officers were: G. E. Buchanan, president and director; A. J. Fortens, vice-president and director; Frank Cadesky, secretary-treasurer and director; N. B. Sheriff, and Norman Lamport, Directors. The head office is at Suite 503, 365 Bay Street, Toronto 1. The mine address is Box 739, Cobalt.

Deer Horn Mines Limited leased then purchased in 1963, the Crosswise Lake O'Brien property from Agnico Mines Limited. The property consists of 14 claims in Coleman township, District of Timiskaming, about 1-1/2 miles east of Cobalt.

The mine operated from 3 January to 30 December, the mill from 3 January to 29 July 1966.

A total of 2,006 feet of drifting, 380 feet of crosscutting and 1,398 feet of raising was completed in 1966. Total development footage to 31 December 1966 was as follows: 48,797 feet of drifts; 16,206 feet of crosscuts; 18,108 feet of raises. Some 184 diamond-drillholes, totalling 24,224 feet, were drilled from underground.

A total of 13,333 tons of ore was hoisted; 13,695 tons were milled at an average of 90 tons per working day from 3 January to 29 July, 1966.

The following is taken from the company annual report for the year ending 31 December, 1966:

Summary of Production

		1966	1965	1964	1963
Ore hoisted	tons	13,333	26,183	26,951	30,257
Ore milled	tons	13,695	25,092	27,690	29,584
Silver recovery per ton	oz.	13.0	12.7	15.7	25.3
Total silver recovery	oz.	177,739	319,532	433,417	749,837

Exploration and Development

Exploration, development and production were continued through to August. Then it was decided to suspend milling operations, reduce all costs and concentrate on developing sufficient ore to sustain milling at its more efficient capacity rate and improve the grade of mill rock being processed.

Extensive exploration from the existing underground workings has been carried out north and south of the known ore zone, but to date the success has been confined to this zone. The production in recent years of approximately 3,000,000 ounces of silver has been taken from

new occurrences lying near existing workings east of the shaft above the 800-foot level.

With the deepening of the shaft to the 900-foot horizon, the downward extension of this zone to the northwest has now become accessible for exploration and development. The main drive on the 900-foot level has been following a very strong vein structure for 300 feet and has recently opened up a section of ore about 130 feet in length along the Crosswise Lake Fault. This new structure is located approximately under the centre of Crosswise Lake. It strikes northwest parallel to the shoreline towards the Queen Alexandra claim also owned by Deer Horn and remains totally unexplored in this direction. Although some exploration is being carried out on other potential ore structures, the main accent is now on development of this new structure.

The average number of employees was 43 - 29 underground and 14 on surface. G. A. Smith was mine manager and J. E. Armstrong, the consulting engineer.

<u>Production and Process Data</u>	<u>O'Brien Mill</u>
Mine Production (Tons per day)	100
Mill Production (Tons per day)	100
Quantity of Tailings (Tons per day)	98

Production and Process DataO'Brien Mill

Chemical process reagents used, quantities and suppliers	) Soda Ash - 0.4 lb./ton - Allied
	) Chemical
	) Xanthate - 0.4 lb./ton - Cyanamid
	) Aerofloat
	) #208 - 0.02 lb./ton - Cyanamid
	) # 25 - 0.04 lb./ton - Cyanamid
) # 65 - 0.2 lb./ton - Cyanamid	
) Copper Sulphate - 0.07 lb./ton -	
	Canadian Refineries

Volume of water pumped to Mill 72,000 gpd

Source of Mill water North end of Peterson Lake

Point of Discharge of Tailings North end of Crosswise Lake

Point of Discharge of Mine Water East side of Crosswise Lake

Approximate ore assay 10 ounces per ton silver

Operating Schedule:

	<u>Mine</u>	<u>Mill</u>
No. of Employees -	26	12
No. of Shifts -	2	3
Days per week -	5	5
Hours per day -	16	24

GLEN LAKE SILVER MINES LIMITED

Glen Lake Silver Mines Limited was incorporated in June 1960 with an authorized capitalization of 5,000,000 shares of \$1 par value, of which 3,100,005 shares have been issued. The directors and officers were: Frank Cadesky, president and director; A. J. Fortens, vice-president

and director; B. M. Apple, secretary-treasurer and director; W. P. Armstrong and F. McCluney, directors. The head office is at Suite 503, 365 Bay Street, Toronto 1. The mine address is Box 590, Cobalt.

The property, comprising 2 claims in Coleman township, District of Timiskaming, was formerly known as the Bailey mine. It is located on the west side of Glen Lake, about three miles southeast of Cobalt.

Mining and milling operations progressed from 3 January to 30 December, 1966.

Development work consisted of 128 feet of drifting, 654 feet of crosscutting and 274 feet of raising. Total development footage to 31 December, 1966 was as follows: 5,774 feet of drifts; 6,249 feet of crosscuts; 2,111 feet of raises. Diamond-drilling in 1966 consisted of 72 holes, totalling 10,390 feet from underground.

A total of 5,397 tons of ore was hoisted; 5,574 tons were milled; the mill averaged, including custom milling, 122 tons per working day.

The following is taken from the company annual report for the period from 1 August, 1965 to 31 July, 1966.

Production

Production has come from both Glen Lake and Hiho. The ore from each property is milled separately.

1 August 1965 to 31 July 1966

Glen Lake-Bailey Mine

Milled	tons	4,010
Tails	oz.	6,657
Average mill heads	oz./ton	70.53
Recovery	percent	97.64

Production:

September	oz.	46,084
October	oz.	8,986
December	oz.	35,519
January	oz.	8,420
June	oz.	75,125
July	oz.	<u>102,069</u>
Total silver	oz.	276,204

Total silver production 1 Aug./62 to 31 July/66 - 2,746,182 oz.

1 August 1965 to 31 July 1966

Hiho-Glen Lake Subsidiary

Milled	tons	32,085
Tails	oz.	30,873
Average mill heads	oz./ton	34.57
Recovery	percent	97.21

Hiho-Glen Lake Subsidiary

Production:

August (1/2 month)	oz.	63,832
September	oz.	68,979
October	oz.	118,751
November	oz.	103,749
December	oz.	71,513
January	oz.	102,032
February	oz.	104,912
March	oz.	125,950
April	oz.	103,460
May	oz.	100,780
June	oz.	54,299
July	oz.	<u>60,219</u>
Total silver	oz.	1,078,480

Total silver production 1 Aug./64 to 31 July/66 - 1,927,335 oz.

Production from both mines:

1 Aug./65 to 31 July/66	oz.	1,354,685
Prior to 1 August, 1965		<u>3,318,833</u>
Total silver production, both mines ..	oz.	4,673,518
Silver production, both mines - month of July 1966	oz.	162,289

Diamond-drilling in the Hiho Cleopatra mine shows the downward extension of the various veins to be carrying silver values. Three intersections below the Al7 or Patricia vein showed highgrade silver veins. A new crosscut is to be driven from the 233-foot level of the shaft which is 50 feet below the second or 183-foot level. The various veins will be developed at this new depth.

Stope preparation at the Hiho Giroux Lake Mine is continuing along the 457 feet of ore found on the 291-foot level below Giroux Lake. The vein shows native silver and excellent grade of ore.

The average number of employees was 31 - 16 underground and 15 on surface. M. C. Halstead is the General Manager.

HIHO SILVER MINES LIMITED

Hiho Silver Mines Limited was incorporated in February 1963. It is a wholly owned subsidiary of Glen Lake Silver Mines Limited, with further details as to directors, officers and operations recorded under Glen Lake in this report. The head office is at Suite 503, 365 Bay Street, Toronto 1. The mine address is Box 590, Cobalt.

The property comprises 430 acres in Coleman and Gillies townships, District of Timiskaming.

Operations proceeded from 3 January to 30 December, 1966.

Development footage consisted of 1,488 feet of drifting,

1,378 feet of crosscutting, and 587 feet of raising. Total development footage to 31 December, 1966 was 4,909 feet of drifts, 7,700 feet of crosscuts and 587 feet of raises. Diamond-drilling consisted of 190 holes totalling 27,688 feet from underground and 9,438 feet from surface.

A total of 38,277 tons of ore was hoisted; 31,468 tons were custom milled at Glen Lake.

The average number of employees was 71 - 43 underground and 28 on surface. M. C. Halstead is General Manager.

Kerr Lake Property

Draining of Kerr Lake is proceeding prior to recommencement of mining operations. The ore stockpiled at this site is being transported to the La Rose Mill which Hiho is purchasing from Silver Town.

Production and Process Data

Mine Production	2,871 tons per month (average)
Mill Production	2,622 tons per month (average)
Quantity of Tailings	109,000 gallons per month
Chemical process reagents used, quantities and suppliers	) C.I.X. 51 - 0.28 lb./ton - C.I.L.
	) Dowfroth #250 - 0.01 lb./ton - Dow Chemical
	) Soda Ash - 0.34 lb./ton - Cobalt Refinery
	) Aerofloat #25 - 0.16 lb./ton - Cyanamid
Volume of water pumped to Mill	125,000 gallons per month
Source of Mill water	North end of Glen Lake.

NOTE: The above figures are for Hiho and Glen Lake. Hiho is purchasing the La Rose Mill from Silver Town in order to mill ore from the Kerr Lake stockpile.

R. C. McALLISTER - BUFFALO LEASE

R. C. McAllister and his partner, A. P. Cloutier, are operating, by lease, the Buffalo property which comprises some 40 acres in Coleman township, District of Timiskaming. The address of the lessee is Box 283, 56 Jamieson Street, Cobalt.

Work continued from 1 June to 31 October, 1966.

A vein intersected by previous drilling is being explored by sub-drifting from an old stope 50 feet below surface; some 30 feet of drifting, and 20 feet of crosscutting had been completed at year end. Surface trenching some 200 feet long, averaging 3 feet in depth and three diamond-drillholes totalling 215 feet from underground, had also been completed.

SILVERFIELDS MINING CORPORATION LIMITED

Silverfields Mining Corporation Limited was incorporated in September 1962 with an authorized capitalization of 3,000,000 shares of \$1 par value of which 1,500,005 shares have been issued. The directors and officers are: N. B. Keevil, president and director; Stephen Kay,

vice-president and director; Sir Michael Butler, Bt., secretary and director; J. H. Hirshhorn and D. A. Perigoe, directors; J. B. Anderson, general manager; J. H. Westell, treasurer; D. S. Brown, assistant secretary. The head office is at Suite 1000, 11 Adelaide Street West, Toronto 1. The mine address is Cobalt.

The property consists of four claims comprising 67 acres in Coleman township, District of Timiskaming. This was formerly known as the Alexandra property; it is located between Glen Lake Silver Mines and Silver Summit Mines on Diabase Mountain.

Mining and milling operations continued throughout 1966.

Development footage in 1966 consisted of 5,234 feet of drifting, 937 feet of crosscutting, and 295 feet of raising. Total development footage to 31 December, 1966 was as follows: 12,258 feet of drifts; 5,796 feet of crosscuts; 1,221 feet of raises. Some 250 diamond-drillholes totalling 25,389 feet were completed from underground.

Some 72,302 tons of ore was hoisted; 74,847 tons were milled at a daily average of 205 tons.

The following is taken from the company annual report for the year ending 31 August, 1966.

Production

Custom milling was continued until December 1965, with 11,750 tons being treated. For the remainder of the fiscal year, ore was

milled in the company mill which treated 53,334 tons during the period.

Following tuneup of the circuit, the mill has operated satisfactorily and capacity is now rated at 230 tons per day.

	<u>1966</u>	<u>1965</u>
Ore milled ton	65,084	37,041
Silver recovered ton	1,423,971	1,232,367
Tailings oz./ton	0.41	0.69
Calculated heads oz./ton	22.29	33.96
Recovery percent	98.10	97.97

In addition to the silver, 63,609 pounds of cobalt and 80,098 pounds of copper were produced.

Lower costs due primarily to higher tonnage milled and operation of the company's own mill have permitted lower grade material to be mined at a profit. This policy is reflected in the reduced grade of ore milled during 1966 as compared to the previous year.

Operating Costs

The following is a comparative analysis of operation costs per ton milled.

	<u>1966</u>	<u>1965</u>
Mining	\$ 4.13	\$ 6.03
Milling	2.45	4.42
Exploration and development	3.67	4.26
Mine general and administrative expense	1.59	2.01
Head office and corporate expense	<u>0.60</u>	<u>1.01</u>
Cost per ton milled	<u>\$12.44</u>	<u>\$17.73</u>

Exploration

Diamond drilling in the mine area was largely confined to exploring the vertical extent of the main vein. Detailed drilling to the north and south of the No. 2 vein over a 600-foot strike length indicates the upward extension of the vein system through the quartzite horizon. This extension ranges 70 to 90 feet above the third level. Ore values are erratic, although the structure is generally strong with distinct contacts in the walls.

Drilling below the fifth level on known veins indicates vein penetration in the range of 100 feet. Ore values extend about 35 to 50 feet below the fifth level on at least three veins.

A drilling programme was carried out in the southeast section of the property by drilling from the underground workings of the Hiho property. Several ore sections were encountered at and below the third level horizon. These will be explored later by crosscutting from the present Silverfields workings.

Ore Reserves

After the milling of 65,084 tons during 1966, indicated ore reserves were still maintained at the level of previous years. In addition, broken ore reserves now total 29,400 tons.

The average number of employees was 82 - 46 underground and 36 on surface. W. C. Summers is the Mine Manager.

Production and Process Data

Silver Summit Mill

Mine Production (Tons per day)	329
Mill Production (Tons per day)	235
Quantity of Tailings (Tons per day)	230
Chemical process reagents used and quantities	Xanthate - 0.5 lb./ton Frother - 0.02 lb./ton
Supplier of Chemical Reagents	Cyanamid
Volume of water pumped to Mill	288,000 gpd
Source of Mill water	South-east end of Cart Lake
Point of Discharge of Tailings	South-west end of Cart Lake
Point of Discharge of Mine Water	West side of Glen Lake
Approximate ore assay	30 ounces per ton silver

Operating Schedule:

No. of Employees	- 75
No. of Shifts	- 21
Days per week	- 7
Hours per day	- 24

SILVER MILLER MINES LIMITED

Silver Miller Mines Limited was incorporated in January 1946, with an authorized capitalization of 3,000,000 shares of \$1 par value; in 1952 the number of shares was increased to 4,000,000; in 1953 to 5,000,000 and in 1960 to 7,000,000 of which 6,646,181 shares have been issued. The directors and officers were: Murray Cooper, president and director; C. G. Gray, vice-president and director; J. M. Wainberg, secretary-treasurer and director; H. B. McLean, mine manager and director; E. F. Griffith, E. F. Furnise and W. A. Carter, directors. The head office is at 714, 62 Richmond Street West, Toronto 1. The mine address is Drawer 230, Cobalt.

The property formerly known as Conisil Mines, consists of about 270 acres in Coleman township, District of Timiskaming and comprises the following properties: Conisil, 40 acres; Hargraves, 80 acres; Marger, 90 acres; Gem, 20 acres; Badger, 40 acres.

Mining operations progressed from 1 January to 31 December, 1966. The mill was idle.

Development work in 1966 consisted of 56 feet of crosscutting and 17 feet of raising. Total development footage to 31 December, 1966 was as follows: 3,798 feet of drifts; 1,279 feet of crosscuts; 3,356 feet of raises. Some 20 diamond-drillholes totalling 12,273 feet were completed from underground. A total of 263 tons of ore was hoisted and stockpiled.

The average number of employees was 5 men on surface; H. B. McLean is the Manager.

SILVER REGENT MINES LIMITED

Silver Regent Mines Limited was incorporated in January 1962 with an authorized capitalization of 5,000,000 shares of no par value, of which 3,025,005 shares have been issued. The directors and officers were: G. E. Buchanan, president and director; A. J. Fortens, vice-president and director; N. B. Sheriff and N. W. Lamport, directors; Frank Cadesky, secretary-treasurer. The head office is at Suite 503, 365 Bay Street, Toronto 1. The mine address is Cobalt.

The property comprises nine claims, about 400 acres, located in Bucke and Coleman townships, District of Timiskaming. It includes the former Genesee property and an adjoining property, leased from Agnico Mines, formerly known as Nipissing North.

Operations progressed from 1 January to 31 December, 1966.

Some 26 diamond-drillholes totalling 7,031 feet were completed from surface and a total of 17,586 feet of diamond-drillholes was completed from underground in 1966.

Underground diamond-drilling was still in progress, and included long holes on the 500-foot level being drilled into the Silver Belle property to the south of the Genesee, as well as surface drilling on the Nipissing North claim.

The diamond-drilling was by contract, under the direction of J. E. Armstrong, Manager.

SILVER TOWN MINES LIMITED

Silver Town Mines Limited was incorporated in January 1963 with an authorized capitalization of 5,000,000 shares of \$1 par value, of which 3,967,505 shares have been issued. The directors and officers were: J. P. Arnott, president and director; A. J. Fortens, vice-president and director; Frank Cadesky, secretary-treasurer and director; N. W. Lamport and R. J. Murphy, directors. The head office is at Suite 503, 365 Bay Street, Toronto 1. The mine address is Box 800, Cobalt.

The property comprises about 258 acres and consists of several claims adjacent to, and embodying Peterson Lake, in Coleman township, District of Timiskaming.

Operations proceeded from 16 June to 31 December, 1966.

The property was reopened during the summer after being dormant since October 1964. A new headframe was erected at the old Peterson Lake No. 1 shaft, the mine was dewatered and a hoisting plant installed and surface buildings constructed. Exploration and development has been confined to the 200-foot level; the sinking of an inclined winze from this level was started. The company purchased the old La Rose mill from Silver Miller Mines Limited, but has sold the mill to

Hiho Silver Mines Limited and will mill its ore in the Deer Horn - O'Brien Mill.

Development work in 1966 consisted of 64 feet of drifting, 132 feet of crosscutting, and 95 feet of raising. Four diamond-drillholes, totalling 844 feet were completed from underground.

Production and Process Data

Mine Production	2,000 tons (July and August 1967)
Mill Production (Tons per day)	-
Quantity of Tailings (Tons per day)	-
Chemical process reagents used and quantities	-
Supplier of Chemical Reagents	-
Volume of water pumped to Mill	-
Source of Mill water	-
Point of Discharge of Tailings	-
Point of Discharge of Mine Water	East end of Peterson Lake
Approximate ore assay	Silver: 27 ounces per ton

Operating Schedule:

No. of Employees	-	29
No. of Shifts	-	10
Days per week	-	5
Hours per day	-	16

NOTE: There is no mill at this site. Ore will be custom milled at the O'Brien Mill.

SUDBURY CONTACT MINES LIMITED

Sudbury Contact Mines Limited was incorporated in October 1927 with an authorized capitalization of 6,000,000 shares of \$1 par value, of which 4,955,000 shares have been issued. The directors and officers were: Paul Penna, president and director; Julius Osheroff, vice-president and director; W. L. Hogarth, Jr. and C. P. McTague, directors; R. F. Righton, secretary-treasurer. The head office is at Suite 1101, 365 Bay Street, Toronto 1; the mine address is Box 9, Cobalt.

The property, formerly known as the Provincial Mine, consists of approximately 40 acres in Gillies Limit, District of Timiskaming.

Operations progressed from 1 January to 31 December, 1966. Development work consisted of some 320 feet of drifting, 410 feet of crosscutting and 165 feet of raising. Some 58 diamond-drillholes totalling 12,225 feet were completed from underground.

Some 500 tons of ore was hoisted and stockpiled.

The average number of employees was 6 - 4 underground and 2 on surface; L. J. Cunningham was Mine Manager.

The Future

As already stated, exploration and development are proceeding and several properties are being rehabilitated. Although it is not possible to make predictions for further ahead than the immediate future, the ever widening gap between production and consumption of silver will undoubtedly lead to higher prices for the metal, which should stimulate greater interest in the camp.

While it is believed that production of silver at the camp will never again approach that of the early years, solidly based steady activity is indicated for the foreseeable future.

DATA SHEET COBALT AREA MINES

Name of Mine	Date of Start Up or Renewed Operations	Date of Close Down	Mining Tonnage Yearly	Name of Mill	Yearly Mill Tonnage	Tailings Disposal Area	Tailings Volume Cu. Yds.
Agnico Mines Limited	Jan. 1953			Penn	47,550	Glen Lake	38,600
Cart Lake		Dec. 1966	6,096		6,096*		
Agaunico		June 1960	D. Drilling		Nil		
Cobalt Lode)		Mar. 1966	2,950		2,950*		
Christopher)		Mar. 1966					
O'Brien		July 1966	5,260		5,260*		
Nip. 407	June 1963	-	29,950		29,950*		
Tailings Mill			180,000	Agnico Tailings Mill	180,000	Cobalt Lake	146,000
Beaver and Timiskaming		Nov. 1958	-	-	-		
Chitaroni Minerals Limited	Sept. 1962 Lease Prop. from Agnico Little Nip.	-	1,800	Custom milled at Penn	-	-	-
Deer Horn Mines Ltd.	Dec. 1950		13,300	O'Brien	13,700	Cross Lake	11,200
Glen Lake Silver Mines Ltd. (Bailey)	June 1960		5,400	Glen Lake	5,575	Glen Lake	4,550

* These milled tonnage figures are included in the Agnico (Penn Mill) tonnage total.

Name of Mine	Date of Start Up or Renewed Operations	Date of Close Down	Mining Tonnage Yearly	Name of Mill	Yearly Mill Tonnage	Tailings Disposal Area	Tailings Volume Cu. Yds.
Hiho Silver Mines Ltd. University #3 Cleopatra Main Crown Reserve and Kerr Lake	Feb. 1963 June 1967		38,300 200 tons/day	Glen Lake La Rose (Silver Miller)	31,500 200 tons/day	Glen Lake Creek at North end of Cobalt Lake	25,800 160 per day
Silverfields Mining Corp. Limited (Alexandra)	Sept. 1962		72,300	Silver Summit	74,800	Cart Lake	61,000
Silver Monarch Mines Limited (20th Century)	June 1967		Exploration	-	-	-	-
Silver Miller Mines Ltd.	Jan. 1946	-	260	Stockpiled	-	-	-

Name of Mine	Date of Start Up or Renewed Operations	Date of Close Down	Mining Tonnage Yearly	Name of Mill	Yearly Mill Tonnage	Tailings Disposal Area	Tailings Volume Cu. Yds.
Silver Town Mines Ltd. (Peterson Lake)	Jan. 1963	-	15,000 (Est.)	O'Brien (Custom)	15,000	Cross Lake	12,300
Sudbury Contact Mines Limited (Provincial)	Oct. 1927	-	2,000	Penn (Custom)	2,000	Glen Lake	1,600

APPENDIX 3
ANALYTICAL RESULTS

ANALYTICAL RESULTS

Sample Number	5-Day B.O.D.	SOLIDS			pH	ARSENIC		Cobalt as Co	Copper as Cu	Nickel as Ni	Silver as Ag	Sulphide as H ₂ S
		Total	Susp.	Diss.		Total	Soluble					
1	1.8	54	4	50	7.8	0.00	0.00	0.0	0.00	0.0	0.00	0.0
2	3.6	118	11	107	8.3	2.4	0.59	0.2	0.03	0.19	<0.01	0.0
3	1.0	170	1	169	7.6	5.15	1.35	0.3	0.03	0.20	<0.01	0.0
4	2.1	132	49	83	8.1	1.8	0.84	0.1	0.03	0.19	<0.01	0.0
5	1.6	68	12	56	8.2	1.23	0.31	0.1	0.03	0.06	<0.01	0.0
6	3.2	268	171	97	8.3	1.81	0.25	0.2	0.15	0.11	0.03	0.0
7	---	99638	99468	170	8.1	27.25	0.15	1.	0.90	0.87	0.10	0.0
8	4.4	430	372	58	8.1	2.38	0.14	0.15	0.04	0.14	0.01	0.0
1	Flow from Brief Lake to Lake Cobalt											
2	Flow from Lake Cobalt to Mill Creek											
3	Water being pumped from Kerr Lake to Glen Lake											
4	Flow from Glen Lake to Giroux Lake											
5	Flow from Cart Lake to Peterson Lake											
6	Flow from Peterson Lake at Crosswise Lake											
7	Tailings from Deer Horn Mill (O'Brien) to Crosswise Lake											
8	Flow from Crosswise Lake to Farr Creek											

Sample Number	5-Day B.O.D.	SOLIDS			pH	ARSENIC		Cobalt as Co	Copper as Cu	Nickel as Ni	Silver as Ag	Sulphide as H ₂ S
		Total	Susp.	Diss.		Total	Soluble					
9	3.8	170	114	56	8.1	0.48	0.48	0.2	.03	0.07	0.01	0.0
10	2.4	178	94	85	8.1	0.53	0.53	0.1	0.25	0.06	0.01	0.0
9	Farr Creek immediately south of North Cobalt											
10	Farr Creek at Lake Timiskaming											

ANALYTICAL RESULTS

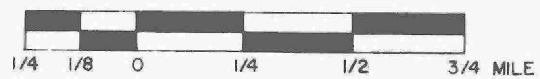
Sample Number	SOLIDS			pH	ARSENIC		C O D
	Total	Susp.	Diss.		Total	Soluble	
1	7810	7566	244	7.5	3.42	0.96	41,900
2	6136	5796	340	8.0	11.8	0.59	6130
3	196048	195738	310	8.1	13.50	0.13	7020
4	136	6	130	7.8	0.80	0.06	8
5	184	3	181	8.2	0.47	0.32	12
6	64016	63716	300	8.0	101.0	0.53	2490
7	266	3	263	7.7	1.2	1.2	8
8	230	14	216	7.9	6.65	1.33	8
1	Mill Creek at culvert under Highway 11						
2	Farr Creek at bridge at Cross Lake						
3	O'Brien Mill tailings discharge to Cross Lake						
4	Crosswise Lake at defunct Agnico Property						
5	Peterson Lake N.E. Corner						
6	Tailings discharge from Glen Lakes Mines						
7	Flow from Kerr Lake to Glen Lake						
8	Flow from Glen Lake to Giroux Lake						

Sample Number	SOLIDS			pH	ARSENIC		C O D
	Total	Susp.	Diss.		Total	Soluble	
9	360	94	266	7.7	1.23	0.38	16
10	1150	279	871	7.6	1.92	0.32	12
11	132200	131960	240	8.4	320.	0.34	3640
12	198	12	186	7.6	0.96	0.96	4
13	274	1	273	7.8	0.32	0.32	4
14	400912	400586	326	8.0	98.50	2.48	4680
15	374	57	317	7.9	2.40	2.40	8
16	528168	527798	370	8.0	1.29	0.50	6320
9	Hilo Mines (University Shaft) Mine water discharge						
10	Silverfields Mine water discharge						
11	Silver Summit Mill tailings						
12	Flow from Cart Lake to Peterson Lake						
13	Silver Town Mines Mine water discharge						
14	Agnico Tailings Mill Tailings						
15	Agnico Tailings Mill Mine Water						
16	Agnico Tailings Mill Tailings						

Sample Number	SOLIDS			pH	ARSENIC		C O D
	Total	Susp.	Diss.		Total	Soluble	
17	272	5	267	7.8	1.45	1.45	4
18	288	1	287	7.9	0.48	0.48	4
19	200	1	199	8.4	0.48	0.48	12
20	388	54	334	8.3	1.38	1.38	16
21	706	506	200	8.1	2.68	0.80	20
22	190	3	187	7.7	0.59	0.59	16
17	Glen Lake North End						
18	Cobalt Refinery over flow to weir						
19	Giroux Lake North Side						
20	Mill Creek discharge from Cobalt Lake						
21	Farr Creek in N. Cobalt area						
22	Giroux Creek South West corner of Giroux Lake						



COBALT AREA



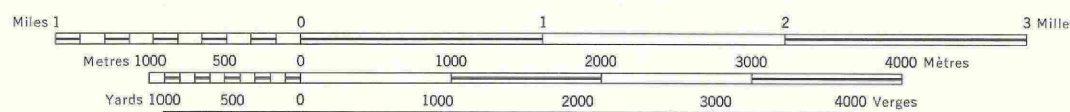


Produced and printed by the SURVEYS AND MAPPING BRANCH, DEPARTMENT OF MINES AND TECHNICAL SURVEYS, 1962, from air photographs taken in 1951 and 1956.

Copies may be obtained from the Map Distribution Office, Department of Mines and Technical Surveys, Ottawa.

COBALT ONTARIO-QUÉBEC

SCALE 1:50,000 ÉCHELLE



Roads:	Routes:	contour interval 50 feet
hard surface, all weather	caoué, toute saison	Élévations en pieds au-dessus du niveau moyen de la mer
loose surface, all weather	caoué, toute saison	North American Datum 1927
loose surface, dry weather	de gravier, toute saison	Transverse Mercator Projection
cart track	de terre	MAGNETIC DECLINATION 9°47' WEST
trail or portage	sentier ou portage	AT CENTRE OF MAP 1962: 9°47' WEST
Railway, normal gauge, single track	Chemin de fer unique à écartement normal	Annual change (decreasing) 2'
Horizontal control point, with elevation	Point géodésique avec cote	
Bench mark, with elevation	Repère de nivellement avec cote	

CONTOUR INTERVAL 50 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Transverse Mercator Projection
MAGNETIC DECLINATION 9°47' WEST
AT CENTRE OF MAP 1962: 9°47' WEST
Annual change (decreasing) 2'

ÉQUIDISTANCE DES COURBES: 50 PIEDS
Élévations en pieds au-dessus du niveau moyen de la mer
Réseau géodésique nord-américain unifié (1927)
Projection transverse de Mercator
DÉCLINAISON MAGNÉTIQUE AU CENTRE
DE LA FEUILLE EN 1962: 9°47' OUEST
Variation annuelle (décroissante) 2'

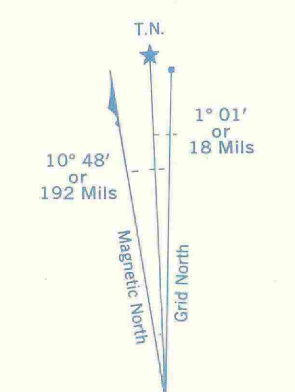
Building	Édifice	Barn	Grange
School	École	Post Office	Bureau de poste
Church	Eglise	Cemetery	Cimetière
Mine or open cut	Mine ou fosse à ciel ouvert		
Lighthouse	Phare		
Power transmission line	Ligne de transport d'énergie		
River with bridge	Rivière avec pont		
Stream, intermittent or dry	Cours d'eau intermittent, ou à sec		
Lake, intermittent, indefinite	Lac intermittent, rive imprécise		
Marsh or swamp	Marais ou marécage		
Depression contours	Courbes de cuvette		

Établi et imprimé par la DIRECTION DES LEVÉS ET DE LA CARTOGRAPHIE, MINISTÈRE DES MINES ET DES RELEVÉS TECHNIQUES en 1962, d'après les photographies aériennes prises en 1951 et 1956.

Ces cartes sont en vente au Bureau de distribution des cartes, ministère des Mines et des Relevés techniques, Ottawa.

Refer to this map as: 31M/5 EAST EDITION 1 ASE SERIES A JS1

CONVERSION SCALE FOR ELEVATIONS
Feet
Meters



Use diagram only to obtain numerical values.
APPROXIMATE MEAN DECLINATION 1962
FOR CENTRE OF MAP
Annual change decreasing 2.0'

GRID ZONE DESIGNATION	100,000 M. SQUARE IDENTIFICATION
17T	NC PC
TO OBTAIN A REFERENCE TO NEAREST 100 METRES	
EXAMPLE: SCHOOL	
EASTING: Read number on grid line immediately to left of point.	99
Estimate tenths of a square from this line nearest to point.	0
NORTHING: Read number on grid line immediately below point.	990
Estimate tenths of a square from this line nearest to point.	8
MILITARY GRID REFERENCE	990498
Nearest similar grid reference 100,000 metres (about 63 miles)	

ONE THOUSAND METRE
UNIVERSAL TRANSVERSE MERCATOR GRID
ZONE 17

TABLEAU D'ASSEMBLAGE DU SYSTÈME DE RÉFÉRENCE CARTOGRAPHIQUE NATIONAL		
31 M/12 W	31 M/12 E	31 M/11 W
31 M/5 W	31 M/5 E	31 M/5 W
31 M/4 W	31 M/4 E	31 M/3 W

COBALT
31 M/5 E
EDITION 1



96936000009459